CALIFORNIA STATE SCIENCE FAIR
2002 PROJECT SUMMARY

Name(s)
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Project Number
J1516

Project Title
Verification of Heisenberg's Uncertainty Principle

Abstract

Objectives/Goals

The objective was to verify both forms of Heisenburg#s Uncertainty Principle given by the equations:
*x*px ~ h
and
*t*E ~ h
Where x is position, p is the momentum, t is time, E is energy of an object and h is Plank#s constant. I hypothesized that these equations will hold true and if one tries to increase the accuracy of one variable the other will become less certain or accurate.

Methods/Materials

I used beams of light to verify the Uncertainty principle. For the first equation I used diffraction to observe the spreading of the beam as the beam passed through a slit. Using a narrow slit is equivalent to reducing the uncertainty in the beam position in the direction transverse to the beam propagation. The Uncertainty Principle predicts that this will increase the uncertainty in the momentum in the transverse direction making the beam diverge. The uncertainty in the propagation vector, *k relates to the uncertainty in momentum of the beam through the relationship
*px = h *kx / 2*.
For the second equation, I used short pulses of light and looked at the pulse duration as the bandwidth of the pulses was varied using a Fabry Perot Interferometer. The bandwidth or frequency content, *n, of the beam relates to the energy uncertainty of the photons through the relationship
*E = h *n.

Results

My results indicate that my hypothesis was correct and the uncertainty principle was verified for both equations. In both cases when the accuracy of one variable was increased the uncertainty in the other variable also increased. In the case of the fist equation, results of the diffraction experiments matched the theoretical predictions within 3%. For the second equation, the product of *n*t, approached the predicted value of 0.31 as the Fabry Perot Bandwidth became significantly smaller than the laser bandwidth.

Conclusions/Discussion

Heisenberg's Uncertainty Principle was verified in both forms.

Summary Statement

My project is about the verification of Heisenberg's Uncertainty Priciples

Help Received

Father helped with identifying project, getting equipment for experiment and collecting data. Some experiments were performed at TRW Inc.